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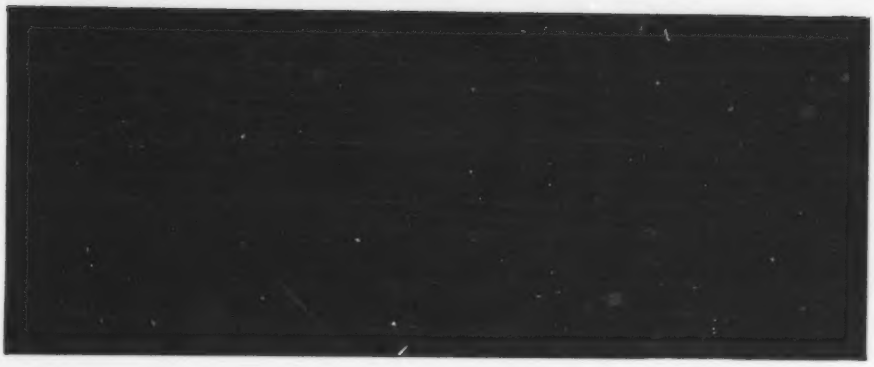

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Nutritional Evaluation of Low-Mucilage Canola Meal

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NUTRITIONAL EVALUATION OF LOW-MUCILAGE CANOLA MEAL

(Final Report on SARF Project 2-85-04)

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Background and Objectives

The physical behaviour of canola seed is a critical factor affecting the ease and efficiency of extraction of the oil in the crushing plant. Differences are recognized between species, Brassica napus and B. campestris and other factors such as environmental ones may also be involved. It was suggested that the mucilage content of canola seed could be responsible and it was known to be present in variable amounts among different Brassica seeds. It was possible that mucilage content of canola seed might not only affect oil extraction but might affect the quality and nutritional value of canola meal (CM). Since mucilages would not likely be changed significantly during the crushing and extraction processes, the mucilage content in the CM would amount to nearly twice the percentage present in the original seed that was crushed.

Mucilages are starch-like compounds found naturally in many plant seeds. These substances tend to be poorly digested by monogastric animals and may also interfere with the absorption of nutrients. The viscous nature of mucilages gives them adhesive properties which are sometimes noticeable after the diet of which they are part has been exposed to an animal's saliva or in the feces of animals consuming the feed. This necessitates greater care and effort in the cleaning of pens and feeders.

Canola seed contains mucilage in varying concentration depending on the cultivar but commercial CM can contribute appreciable amounts of mucilage to a swine diet. The development of a low-mucilage (low-M) strain of canola (derived from Candle), made it possible to compare the effects of the meal from this strain with that of Candle, a cultivar containing the regular concentration of mucilage, on the gains, feed efficiency and nutrient digestibility of growing pigs. The effect of an enzyme, beta-glucanase, which has been shown to improve the digestibility of barley by chickens was also tested to see if this particular carbohydrate-digesting enzyme would improve feed utilization and possibly provide some indication about its use for mucilage breakdown in the digestive system.

Experimental Method

The low-M and Candle canola seed batches were processed at the POS Pilot Plant, University Campus, Saskatoon, in order to extract the oil and prepare the meals.

Twelve barley:wheat (2:1) diets were formulated to contain 0, 6 or 12% of each CM with and without the addition of the enzyme source (Table 1). The grains were ground in a hammermill fitted with a 3.2 mm (1/8") screen. Diets were fed in meal form.

Seventy-two crossbred barrows, mainly the progeny of Landrace-Yorkshire crossbred sows and Lacombe boars, were randomly allotted to test diets and fed according to a controlled feeding schedule (three times daily to 45 kg liveweight and twice daily thereafter) throughout the liveweight range of 23-57 kg. Pig weights and feed intakes were measured weekly. The trial was terminated at the end of the grower period due to the limited supply of CM.

To determine the digestibility of crude protein (CP) and energy in each CM, 0, 15 or 30% of each CM or 30% CM plus 0.25% enzyme source was incorporated into a barley:wheat (2:1) plus soybean meal basal diet similar to that used in the feeding trial. Supplemental vitamins and minerals were added along with 0.5% chromic oxide as a fecal marker. The test diets were fed to crossbred barrows weighing 35-45 kg initial weight in two successive feeding periods of 14 days each. Each diet was fed to two pigs in each feeding period. Fecal samples were collected during the last four days of each period. Samples from each pig were pooled within each collection period, then blended, dried and ground in preparation for analysis.

Methods of the Association of Official Analytical Chemists (1980) were used to determine moisture, CP, ash, ether extract, crude fiber (CF) and acid detergent fiber (ADF). Glucosinolate concentrations in CM were measured by Dr. D.I. McGregor, Agriculture Canada Research Station, Saskatoon, using the gas chromatographic method of the Canadian Grain Commission-Grain Research Laboratory, Winnipeg. Methods used for the remaining analyses (gross energy, neutral detergent fiber (NDF), ADF-lignin, lysine, available lysine, chromic oxide) were selected from scientific literature and have been the basis of the data in numerous publications originating from this laboratory. Mucilage content was determined by three methods. The method of Woods and Downey (1980) provided a gravimetric estimate and viscosity, and the other method (L. Van Caeseek, J. Mills and L. Cooke, 1986, personal communication) was based in microscope examination of a mucilage halo around seeds immersed in distilled water. Statistical analysis appropriate for the particular designs of these experiments was done according to Statistical Analysis Systems (SAS) procedures.

Results and Discussion

The mucilage evaluations for the low-M and Candle CM were, respectively, for the three methods: (a) 108 and 396 mg mucilage/100 gm seed, (b) viscosity 69 and 79 vs water at 64, and (c) 2 and 25% of seeds showing the mucilage halo. The low-M meal contained more CP, lysine and available lysine compared to the Candle CM (Table 2). The CP concentration in the low-M meal was equivalent to 40.4% (90% dry matter basis) which is higher than the level of about 37% usually found in commercial CM. The contents of gross energy, ash and ether extract (fat) were similar in the two meals. There was less fiber (CF, NDF, ADF; Table 2) in the low-M meal. ADF-lignin is a component of these fiber fractions and was markedly lower in the low-M meal. The fiber concentration in soybean meal was less than that in either CM. Fiber is largely indigestible by monogastric animals such as the pig and therefore represents a portion of the energy in the feed that cannot be utilized by this animal. In addition, it is well established that a high concentration of fiber in the diet can decrease the digestibility of other nutrients. A reduction in fiber level such as that seen in the low-M CM is therefore an advantage.

Both canola meals showed concentrations of glucosinolates greater than those commonly found in commercial CM (10-23 µmoles/g oil-free dry matter) and above the upper limit of 30 µmoles/g oil-free air-dry meal set out in the canola specifications. Meal exceeding these limits does not qualify as canola. Both cultivars were of the low glucosinolate type. The reason for these high concentrations is not clear, although it is possible that condtions during processing of the meals may not have been appropriate to reduce the glucosinolate concentrations to those found in the commercial meals.

The composition data clearly indicate that the low-M CM was superior to the Candle CM, however, the Candle CM proved to be below normal in quality. Therefore no conclusions should be drawn regarding protein and fiber characteristics of these two CM strains from these data, nor was it the intention of this project to make such comparisons.

There was no effect of mucilage content in the CM on gains, feed intakes or feed:gain ratio of pigs fed diets containing the two meals (Table 3). These performance figures compare favourably with average values of 0.66 kg daily gain and a feed:gain ratio of 2.72 for 20-60 kg pigs as reported by the National Research Council of the U.S. National Academy of Sciences (1979). There was a slight (4.5%) increase in gains when the enzyme, beta-glucanase, was added but this was largely due to increased feed intake. The effect was not observed when gains were adjusted to a constant feed intake (Table 3).

Increasing the CM concentration from 0 to 12% of the diet resulted in some decrease in gains and feed intakes (Table 3), similar to observations that have been made previously. Gains adjusted to constant feed intakes were similar at all CM levels, indicating that differences in feed intake were largely responsible for the decreased gains. Based on previous research, the lower feed intakes may have been due to poor palatability resulting from the glucosinolates which were present in higher than usual concentrations.

Digestibility coefficients for CP in diets containing low-M CM were similar to those for the basal diet, indicating that CP digestibility in this CM was similar to that of the basal grains (Table 4). Coefficients for those diets containing Candle meal were significantly lower. CP digestiblity coefficients were 81.4% for the low-M meal and 74.9% for Candle CM, probably reflecting the higher fiber content.

Addition of either CM to the basal diet caused a significant reduction in energy digestibility but Candle meal, especially at 30% of the diet, caused the greatest decrease (Table 4). Energy digestibility coefficients for the low-M and Candle meals were 71.7 and 65.1%, respectively. There was marginal improvement in energy digestibility in the Candle meal with enzyme addition but this did not happen with the low-M meal.

This apparent improvement in energy digestibility (76.8 vs 75.8%) in diets containing Candle CM appears to be associated with carbohydrate digestion since protein digestion was not improved by the enzyme supplement. It is possible that the enzyme affected the mucilage content or that other enzymes in the relatively crude enzyme source affected certain carbohydrate component(s). However the amount of improvement obtained would not be cost-effective in practical use.

Digestibility coefficients of 74.9% for CP and 65.1% for energy in Candle CM were lower than previously reported values of 81 and 71%, respectively. The lower digestibility of Candle meal in this investigation was probably due in part to the higher fiber content of approximately 14% compared to reported values of 10-11% of the air-dry meal. Despite the somewhat lower digestibility coefficients for CP and energy in Candle meal compared with the low-M meal, this was not reflected in the performance of pigs in the feeding trial probably because the CM level in the diets was limited to 12%.

Digestibility coefficients of 81.4% for CP and 71.7% for energy in the low-M meal are close to literature values noted above for Candle meal. Except for its slightly higher CP concentration, in terms of its monetary value as a livestock feed, the low-M meal appears to be very similar to Candle meal and the commercial CM now being produced.

The results of these studies indicate that there is no obvious advantage in producing low mucilage canola seed as far as the feeding value of the resulting CM is concerned. Such CM had feeding value, for pigs, similar to previous evaluation of Candle CM. If low mucilage seed offers advantages to the crusher, it is probable that the meal would not differ appreciably from CM that is normally produced.

Table 1. Formulas of diets fed to pigs[1] in the feeding trial (%, air-dry basis)

Ingredient	Canola meal (%)		
	0	6	12
Barley	58.66	57.43	56.20
Wheat	29.36	28.74	28.12
Soybean meal	8.30	4.15	-
Canola meal	-	6.00	12.00
Dicalcium phosphate	1.80	1.80	1.80
Ground limestone	1.00	1.00	1.00
Iodized salt	0.50	0.50	0.50
Vitamin-mineral premix	0.25	0.25	0.25
Lysine·HCl, feed grade	0.13	0.13	0.13
Enzyme source[2]	-	-	-

1 Formulated to contain 16.5% crude protein (N x 6.25).
2 A corresponding set of 3 diets was formulated to contain 0.25% enzyme source. A series of six diets was prepared for each canola cultivar.

Table 2. Chemical composition of low mucilage canola meal (CM) compared with Candle CM and soybean meal (dry matter basis)

Component	Low mucilage CM	Candle CM	Soybean meal
Gross energy, MJ/kg	20.67	20.80	19.58
Crude protein (N x 6.25), %	44.90	39.71	50.36
Ash, %	6.04	6.27	6.81
Ether extract (fat), %	4.68	4.91	1.35
Crude fiber, %	8.50	14.24	4.19
Acid detergent fiber (ADF), %	14.65	20.43	6.47
Neutral detergent fiber, %	18.32	25.90	9.12
ADF-lignin, %	2.93	9.37	1.05
Total lysine, %	2.66	2.23	3.17
Available lysine[1], %	2.34	2.00	3.01
Total glucosinolates[2], µmoles/g	42	37	-

1 Determined chemically.
2 Sum of aliphatic glucosinolates (butenyl, pentenyl, hydroxybutenyl, hydroxypentenyl).

Table 3. Daily gains and efficiency of feed utilization of pigs (23-57 kg liveweight)

Experimental variable[2]	n	Daily gain (kg)	Daily feed (kg)	Feed:gain ratio	Adjusted daily gain[1] (kg)
Mucilage level					
low	36	0.68	1.80	2.64	0.69
regular (Candle)	36	0.69	1.82	2.65	0.68
Enzyme					
nil	36	0.67*b*	1.79	2.67	0.68
added	36	0.70*a*	1.82	2.61	0.69
Canola meal, %					
0	24	0.72*a*	1.87*a*	2.61	0.70
6	24	0.68*ab*	1.83*a*	2.68	0.67
12	24	0.66*b*	1.72*b*	2.63	0.68

1 Adjusted to constant feed intake for all animals.
2 Significant interaction effects among experimental variables were not detected ($P<0.05$).
a-b Means followed by different letters are significantly different ($P<0.05$).

Table 4. Digestibility of crude protein and energy in swine diets containing 0, 15 or 30% low mucilage (low-M) or Candle canola meal (CM) and in the meals themselves

Treatment	Digestibility coefficient	
	Crude protein (%)	Energy (%)
Basal diet (0% CM)	80.6*a*	81.2*a*
Basal + 15% low-M CM	79.9*ab*	79.1*b*
Basal + 30% low-M CM	81.2*a*	78.2*b*
Basal + 30% low-M CM + enzyme	80.6*a*	78.7*b*
Basal + 15% Candle CM	78.4*bc*	78.3*b*
Basal + 30% Candle CM	78.1*c*	75.8*d*
Basal + 30% Candle CM + enzyme	78.6*c*	76.8*c*
Low-M CM	81.4	71.7
Candle CM	74.9	65.1

a-d Means within each column followed by different letters are significantly different ($P<0.05$).

2-8420

CANOLA PRESS CAKE AS A HIGH ENERGY, HIGH PROTEIN ANIMAL FEED

J.M. Bell and M.O. Keith

ABSTRACT

Samples of canola seed, press cake and meal were obtained from runs in four successive weeks from each of seven crushing plants in Western Canada. Each sample was subjected to analysis to determine protein, ether extract (oil), glucosinolates and myrosinase enzyme activity. One lot of press cake was used to determine digestibility of energy and protein for pigs. Press cake contained 21% oil (range 17.5 to 26.7) and 33% crude protein (27.7 to 36.5). Digestibility coefficients were 75.2% for energy and 81.5% for crude protein. The average digestible energy value was estimated to be 4100 kcal/kg but this varies with the amount of oil in the sample. Using the Peterson formula for estimating the monetary value of a feed, and using good barley and canola meal as representative energy and protein feeds, it is tentatively estimated that average press cake may be worth from 1.7 to 2.7 times the price of good barley when used in swine feeds as a competitive source of digestible energy and protein.

BACKGROUND AND OBJECTIVES

Canola press cake is the partially extracted material that has been flaked, cooked and put through a hydraulic expeller in a crushing plant. This process is intended to inactivate the enzyme myrosinase which can, under appropriate moisture and temperature conditions, hydrolyze glucosinolates which in turn may affect thyroid activity and animal performance if such material is consumed. Press cake may be a potentially useful energy and protein source in swine diets because of its relatively high oil content and the high quality protein of canola seed and meal. However, no study has been made of press cake as a feedstuff, consequently this study was undertaken to characterize the nutrient composition, the glucosinolate content and the digestibility of press cake in order to establish its nutritional, toxicological and economic characteristics as a potential feedstuff for swine.

The nutritional values of canola meal, canola oil and canola seed (sound or frost-damaged) have been established. Rapeseed meal produced by the expeller process was usually of low feeding value, in part because of the extreme pressure and heat generated by expelling the maximum amount of oil and in part because rapeseed meal contains much higher levels of glucosinolates than does canola meal. Press cake from canola would be expected to be of far superior quality than expeller rapeseed meal, having incurred little or no heat damage to its protein and having low glucosinolate content. It could be a valuable source of energy and protein in animal diets and therefore should be evaluated.

EXPERIMENTAL METHOD

To determine digestibility of crude protein (CP) and energy in press cake, 0, 20 or 40% press cake was incorporated into a light-weight barley-soybean meal basal diet supplemented with vitamins and minerals and containing 0.5% chromium sesquioxide (Cr_2O_3) as a fecal marker. The test diets were fed to castrate male pigs, 45 kg initial liveweight, in four successive feeding periods each of 9 to 12 days duration. Fecal samples were collected during the last three days of each period. The samples were pooled for each pig within each collection period, blended, dried and ground in preparation for laboratory analysis.

Laboratory analyses were based on the following methods; for moisture and CP, Association of Official Analytical Methods (1980); for ether extract (EE), Swedish tube extraction using petroleum ether as solvent; for gross energy determination of digestibility trial samples, a Parr adiabatic bomb calorimeter, for chromium sesquioxide, the method of Fenton and Fenton (1979). Glucosinolate activity was measured by a gas chromatographic method adapted by Dr. D.I. McGregor at the Agriculture Canada Research Station, Saskatoon, using sinigrin (allyl glucosinolate) as the substrate. Statistical analyses appropriate for the particular experimental design were carried out according to Statistical Analysis Systems (SAS) procedures.

RESULTS AND DISCUSSION

The values for both CP and EE in press cake were intermediate between the corresponding values for whole seeds and meal (Table 1). This reflects the fact that as the oil is progressively extracted, the CP content of the residue is increased. There was generally more plant-to-plant variation in both CP and EE data for press cake compared to seeds and meal. However, for all three forms (seeds, press cake, meal), the CP contents of samples from Plant #6 were consistently lower than for other plants. This may be a reflection of the canola cultivar being processed at the time.

The glucosinolate content (Table 2) varied significantly among crushing plants, in terms of the glucosinolates regularly determined in assessing canola status as well as in terms of the indolyl glucosinolates and the total of these two groups of compounds. Since the values in Table 2 are averages of seed, cake and meal, it is not possible to determine from this table whether the apparent plant-to-plant differences are related to the character of the canola seed available to a particular plant or whether the differences are due to effects of processing on glucosinolate levels in meal or press cake. This aspect is being examined further.

It is evident that as canola seed progressed through the crushing process, the levels of all glucosinolates studied declined (Table 3). On average the regular glucosinolates declined by about one-third and total

indolyl glucosinolates declined by about two-thirds, comparing meal with the original seed. The press cake glucosinolate values resembled those of the seed, indicating that the major decline probably occurred in the desolventizer-toaster during the final treatment of the meal.

The cooking process evidently inactivated the enzyme myrosinase very effectively in all crushing plants, with one possible exception (Table 4). While variability was high relative to the mean values, most samples of press cake showed that over 99% of the myrosinase had been destroyed during either the cooking or the expelling process. Some further inactivaton seems to have occurred in the desolventizer-toaster but at such low levels of myrosinase activity as were found in these meals and in most of the press cake samples, the precision of the assay may be in doubt.

When press cake was added at levels of 20 and 40% of the diet, to a light-weight barley swine grower diet the digestibility of energy was unaffected, indicating that the energy components of press cake, on average, were of similar digestibility to those of the basal diet containing no press cake (Table 5). In the case of CP the digestibility of this nutrient improved with the addition of press cake so the protein in press cake appeared to be more digestible than that of the grain and protein supplement. Using regression methods, it was possible to establish the digestibility of CP as 81.5% and of energy as 75.2% in press cake.

Since the average gross energy value of press cake is about 5470 kcal/kg, as estimated from its oil and meal content, the average digestible energy (DE) value may be assumed to be about 4100 kcal/kg. However, in view of the varying oil (EE) content of press cake, the range of DE values may be about 3900 to 4300 kcal/kg. Such values may be compared with 3480 kcal/kg for wheat or 3220 kcal/kg for barley. They may also be compared with frost-damaged canola seed which contained about 3875 kcal DE/kg, about 20% CP and about 22 to 35% oil depending on the amount of frost damage. The digestibility of energy in ground frost-damaged canola seed was about 60 to 65% compared with 75% for press cake energy and likewise the CP in press cake was more digestible than that of frozen canola (81% vs 62 to 68%, resp.).

The economic value of press cake as a source of DE and protein can be estimated using a modified Peterson formula based on the value of DE and digestible CP in barley and canola meal. Obviously the value of a particular lot of press cake will be affected by the amount of oil left in the product and by the relative value of barley (as a major energy feed) and of canola meal (as a protein supplement). Using the average composition of press cake found in this experiment and assuming that barley was worth $100/tonne and canola meal was worth $150, $200 or $250/tonne, press cake was worth $170, $218 or $266/tonne, increasing as the value of canola meal increased relative to barley.

IMPACT

This experiment has characterized the composition of press cake and the variability within and between canola crushing plants in Western Canada. It was found that myrosinase was effectively inactivated by the press cake stage in most cases but in two plants from 1.5 to 4.0% of the original activity remained. Most of the original content of glucosinolates remained intact in the press cake.
Digestibility coefficients for energy and protein in press cake were high. Based on digestibility and composition data, press cake was found to be worth 1.7 to 2.7 times the price of good barley when the corresponding factors for canola meal were 1.5 and 2.5. This information should be useful in determining whether or not canola crushing plants would be interested in marketing press cake and whether the feed industry would find tne product competitive.

Table 1. Crude protein (CP) and ether extract (EE) (oil content) of canola seeds, press cake and meal (% of dry matter)

Crushing plant	Whole seeds		Press cake		Meal	
	CP	EE	CP	EE	CP	EE
1	24.47†	44.98	35.47	18.13	43.01	2.27
2	24.28	43.52	33.17	24.53	43.06	4.76
3	25.40	42.45	36.05	18.11	42.68	3.92
4	24.28	43.66	36.49	17.48	40.90	4.03
5	23.23	44.97	33.73	21.14	41.81	4.19
6	20.77	45.67	27.68	26.67	36.75	4.39
7	23.17	43.91	31.27	22.43	42.17	3.88
Mean	23.66	44.17	33.41	21.21	41.48	3.92

† Each value represents 4 observations.

Table 2. Variations in glucosinolate content among crushing plants in Western Canada, 1985. Averages of seed, press cake and meal

Crushing plant	Glucosinolates (μmol/g, oil-free dry matter)		
	Regular†	Indolyl‡	Total
1	20*c*§	9*c*	29*d*
2	21*c*	10*b*	31*c*
3	16*e*	13*a*	29*d*
4	18*d*	10*b*	28*d*
5	23*b*	9*c*	32*b*
6	33*a*	9*c*	42*a*
7	19*d*	12*a*	31*c*

† The sum of butenyl, pentenyl, hydroxybutenyl and hydroxypentenyl glucosinolates; those used in determining glucosinolate content of canola meal.

‡ Indolylmethyl- and hydroxyindolylmethyl glucosinolates.

§ Means within columns bearing different letters are significantly different ($P<0.05$).

Table 3. Changes in glucosinolate content of oil-free sample as canola seed passes through crushing plants

Glucosinolate	Seed	Press Cake	Meal
Butenyl	7.4*a*†	7.3*a*	5.0*b*
Pentenyl	2.6*a*	2.5*a*	1.7*b*
Hydroxybutenyl	13.4*a*	12.9*b*	8.8*c*
Hydroxypentenyl	1.1*a*	1.0*a*	0.7*b*
Indolylmethyl	0.6*a*	0.6*a*	0.4*b*
Hydroxyindolylmethyl	13.4*a*	11.5*b*	4.5*c*
Total regular	24.3*a*	23.8*a*	16.2*c*
Total indolyl	14.0*a*	12.0*b*	4.8*c*
Overall total	38 5*a*	35.8*b*	21.0*c*

† See footnote Table 2.

Table 4. Myrosinase activity of press cake and of meal as percentages of the myrosinase activity in the original seed

Sample	Press cake	Meal
Crushing plant		
1	4.15±0.20†	0.22±0.17
2	1.60±1.23	0.15±0.10
3	0.17±0.14	0.03±0.02
4	0.02±0.02	0.01±0.01
5	0.05±0.05	0.47±0.41
6	1.46±0.96	0.15±0.15
7	0.81±0.17	0.00±0.00
Collection period		
1	0.87±0.55	0.01±0.01
2	0.34±0.16	0.32±0.24
3	0.12±0.06	0.20±0.12
4	1.25±0.71	0.06±0.03

† Standard error of the mean.

Table 5. Percentage digestibility of diets containing 0, 20 and 40% press cake and digestibility of press cake energy and protein, estimated by regression methods

Diet component	Press cake in diet (%)			Press cake
	0	20	40	
Dry matter	76.1	75.1	74.1	71.2
Energy	75.6	75.5	75.4	75.2
Crude protein	76.1	77.8	79.4	81.5